

CLAIMS:

We claim:

1. A method for filling a hole with a metal comprising:

5 successively forming an insulating layer, a first mask layer, and a second mask layer on a semiconductor substrate;

etching the first and the second mask layers to form a first and a second masks, each of the first and second masks having a first opening that has a first width;

10 selectively etching the first mask to form a third mask having a second opening that has a second width that is greater than the first width;

etching the insulating layer using the second mask to form a hole having the first width;

forming a metal layer on the insulating layer to fill the hole and the second opening with the metal layer; and

15 removing the third mask and the metal layer to expose an upper surface of the insulating layer.

2. The method of claim 1, wherein forming the third mask includes etching the first mask using an etchant, the first mask having a higher etching selectivity than the second mask with respect to the etchant.

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3. The method of claim 1, wherein forming the first mask layer comprises forming the first mask layer to a thickness of about 150 nm to about 250 nm.

25 4. The method of claim 1, wherein forming the first mask layer comprises forming a layer selected from the group consisting of a fluorine-doped oxide layer, a carbon-doped oxide layer, a silicon-based oxide layer, a hydrogen silsesquioxane (HSQ) layer, a flowable oxide layer, a methylsilsesquioxane based material (LKD) layer, and wherein forming the second mask layer comprises forming a layer selected from the group consisting of a SiON layer, a SiC-based material layer, a Si-based material layer, and a Si-based nitride material

30 layer.

5. The method of claim 1, further comprising removing the second mask prior to forming the metal layer.

6. The method of claim 1, wherein forming the metal layer comprises forming the metal layer by an electroplating process.

7. The method of claim 1, wherein removing the third mask layer and the metal layer comprises using a process chosen from the group consisting of a chemical mechanical polishing (CMP) process and an etch-back process.

8. A method for filling a hole with a metal comprising:
successively forming an insulating layer and a first mask layer on a semiconductor
10 substrate;
etching the first mask layer to form a first mask having a first opening that has a first width;
etching the insulating layer using the first mask to form a hole having the first width;
etching the first mask to form a second mask having a second opening that has a second
15 width that is greater than the first width;
forming a metal layer on the insulating layer to fill the hole and the second opening; and
removing the third mask and the metal layer to expose an upper surface of the insulating
layer.

20 9. The method of claim 8, wherein forming the first mask layer comprises forming the first mask layer to a thickness of about 150 nm to about 250 nm.

10. The method of claim 8, wherein forming the first mask layer comprises forming a layer chosen from the group consisting of a fluorine-doped oxide layer, a carbon-doped oxide
25 layer, a silicon-based oxide layer, a hydrogen silsesquioxane (HSQ) layer, a flowable oxide layer, and a methylsilsesquioxane based material (LKD) layer, and forming the second mask layer comprises forming a layer chosen from the group consisting of a SiON layer, a SiC-based material layer, a Si-based material layer, and a Si-based nitride material layer.

30 11. The method of claim 8, wherein forming the metal layer comprises forming the metal layer by an electroplating process.

12. The method of claim 8, wherein removing the second mask and the metal layer comprises using a process chosen from the group consisting of a chemical mechanical polishing (CMP) process and an etch-back process.

5 13. A method for filling a hole with a metal comprising:

forming an insulating layer on a semiconductor substrate;

successively forming first and second mask layers on the insulating layer;

forming a photoresist pattern on the second mask layer;

etching the first and second mask layers using the photoresist pattern as a mask to form

10 a first mask having a first opening that has a first width and a second mask having a second opening that has the first width;

etching the first mask using an etchant, the first mask having a higher etching selectivity with respect to the etchant than the second mask, to form a third mask having a third opening that has a second width that is greater than the first width;

15 etching the insulating layer using the second mask to form a hole having the first width;

forming a metal layer on the insulating layer to fill the hole and the third opening[with the metal layer]; and

removing the third mask and the metal layer to expose an upper surface of the insulating layer.

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14. The method of claim 13, wherein forming the first mask layer forming a layer selected from the group consisting of a fluorine-doped oxide layer, a carbon-doped oxide layer, a silicon-based oxide layer, a hydrogen silsesquioxane (HSQ) layer, a flowable oxide layer, and a methylsilsesquioxane based material (LKD) layer, and forming the second mask layer

25 comprises forming a layer selected from the group consisting of a SiON layer, a SiC-based material layer, a Si-based material layer, and a Si-based nitride material layer.

30 15. The method of claim 13, wherein the etchant comprises a solution selected from the group consisting of a fluorine solution, an ammonia solution, a hydrogen fluoride solution, and an alkaline ammonia solution.

16. The method of claim 13, wherein forming the metal layer comprises forming a copper layer with an electroplating process.

17. The method of claim 16, wherein forming the copper layer with the electroplating process comprises electroplating with an electrolyte solution that includes about 10 g/liter to about 30 g/liter of copper, about 100 g/liter to about 300 g/liter of H₂SO₄, about 40 ppm to about 120 ppm of chlorine, about 15 ml/liter to about 45 ml/liter of an accelerator, and 5 about 1 ml/liter to about 4 ml/liter of a suppressor.

18. The method of claim 13, wherein removing the third mask and the metal layer comprises using a process selected from the group consisting of a chemical mechanical polishing (CMP) process and an etch-back process.

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19. The method of claim 13, further comprising removing the second mask prior to forming the hole.

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20. A method for filling a hole with a metal comprising:

successively forming an insulating layer and a mask layer on a semiconductor substrate;

forming a first photoresist pattern on the mask layer;

etching the insulating layer and the mask layer using the first photoresist pattern as a mask to simultaneously form an insulating layer pattern having a hole that has a first width and 20 a first mask having a first opening that has the first width;

forming a second photoresist pattern having a pattern width greater than the first width on the first mask;

etching the first mask using the second photoresist pattern as a mask for exposing an upper surface of the insulating layer pattern to form a second mask having a second opening 25 that has a second width greater than the first width;

forming a metal layer on the insulating layer to fill the hole and the second opening; and removing the second mask and the metal layer to expose an upper surface of the insulating layer.

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